The 3D Parker Instability of a Horizontal Magnetic Field and the Formation of Arching Flux Tubes

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Bipolar magnetic regions on the solar surface are believed to correspond to the topmost portions of Ω-shaped arching flux tubes that have risen buoyantly from the base of the solar convection zone, where strong toroidal magnetic fields are generated by the dynamo process. The undular Parker instability is one of the likely mechanisms by which buoyant, arching flux tubes can develop from the toroidal magnetic field. In this talk, I present our recent 3-D simulations of the growth of the undular Parker instability in a horizontal magnetic layer with uni-directional field lines, embedded in an adiabatically-stratified polytropic atmosphere. We consider the limit of very high plasma β, representing the condition at the base of the solar convection zone. The simulations show that distinct arching flux tubes form, and that buoyancy grows exponentially at the apexes of the tubes as a result of the diverging flow of mass from the apexes to the troughs. Even though the initial magnetic field is untwisted, the difference in motion between the apexes and the troughs causes bending and braiding of the longitudinal field lines, whose restoring tension force improves the cohesion of the rising flux tubes in comparison to previous results from 2-D simulations of the rise of horizontal flux tubes.